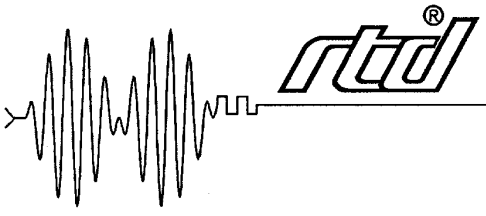
GSM35
900/1800MHz GSM Modem Module

User's Manual

Hardware revision 1.1



Real Time Devices, Inc.

"Accessing the Analog World"®

GSM35
GSM Modem Module
User's Manual

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WARNING

LIFE SUPPORT APPLICATIONS

This product is not designed for use in life support appliances, devices or systems where malfunctioning of these products can reasonably be expected to result in personal injury. RTD customers using or selling this product for use in these applications do so at their own risk and fully agree to indemnify RTD for any damages resulting from such improper use or sale.

SAFETY PRECAUTIONS FOR THE USER

1) AIRCRAFT SAFETY

The TC35 cellular engine used on the GSM35 can interfere with an aircraft's navigation system and it's cellular network. Using your GSM35 on board aircraft is forbidden by law. Failure to comply with this prohibition may lead to temporary suspension or permanent cancellation of cellular services for the person who infringes this prohibition and/or legal action against said person.

2) ENVIRONMENTS WITH EXPLOSIVE SUBSTANCES

Users are not advised to use the GSM35 in automotive service stations. Users are reminded of the necessity to comply with restrictions regarding the use of radio devices in fuel depots, chemical plants and locations where explosives are ignited.

3) ELECTRONICS IN MEDICAL APPLICATIONS

Radio transmitters such as the GSM35 can interfere with the operation of inadequately protected medical devices. Please address all questions to a doctor or manufacturer of the medical device.

4) PRECAUTIONS IN THE EVENT OF LOSS/THEFT OF GSM35 AND SIM CARD

If your GSM35, SIM card or both go missing, notify your network operator immediately in order to avoid misuse.

Revision History

05/04/2002 HW Release 1.0, Preliminary version, released

CE Conformity of TC35 cellular engine:

- **89/336/EC (EMC Directive)**
- **73/23/EC (Low voltage directive)**
- **91/263/EC (telecommunications terminals directive)**

Standards:

- **EMC** **ETS 300 342-1**
- **Safety** **EN60950**
- **GSM Network** **TBR 19, TBR 20**

Notice: We have attempted to verify all information in this manual as of the publication date. Information in this manual may change without prior notice from RTD Finland Oy.

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Chapter 1 - INTRODUCTION

This user's manual describes the operation of the RTD GSM35 integrated global GSM wireless modem designed for mobile, marine, and automotive applications.

Features

Some of the key features of the GSM35 include:

- Low power Dual band Siemens TC35 cellular engine, GSM900/1800Mhz
- 9,6/14,4 kbit/s datarate, group 3 faxes, SMS and SMS cell broadcast
- Onboard SIM-card socket for 3V standard cards
- 16C550 UART interfaces to host computer
- Supports COM1,COM2,COM3,COM4 or COMx
- Available IRQ's 2,5,6,7,10,11,12,14,15
- Status LED indicating GSM activity and status
- 16 TTL I/O's 8 outputs 8 inputs
- +5V only operation, 2.3W typical
- Wide operating temperature range –20 to + 70C guaranteed
- Onboard temperature sensor
- Fully PC/104 compliant, IDAN versions available

The following paragraphs briefly describe the major features of the GSM35. A more detailed discussion is included in Chapter 4 (Hardware description) The boards installation is described in Chapter 2 (Board Installation).

GSM cellular modem

The Real Time Devices GSM35 wireless GSM modem unit provides a direct and reliable GSM connection to stationary or GSM 900/1800 mobile fields around the world. GSM connectivity is achieved using the Siemens TC35 engine. This unit works in the 900/1800MHz band supporting GSM 02.22 network and service provider personalisation.

Connect any standard GSM antenna directly to the OSX connector of the GSM35. The antenna should be connected to the TC35 using a flexible 50-Ohm antenna cable. In IDAN installations the antenna connection is brought to the front side of the IDAN-frame. The antenna used should meet the following specifications: Frequency 890-910MHz (TX), 935-960MHz (RX); Impedance 50 Ohms; VSWR 1,7:1 (TX) 1,9:1 (RX); Gain <1,5dB references to 1/2-dipole; 1W power (cw) max 2W peak at 55 degrees Centigrade.

A SIM-card socket is located on the solder side of the module. The card can only be removed while the TC35 has been placed in shutdown mode. The GPRS35 is also available using the MC35 GPRS Modem. It supports all the features of the GSM35 and, on top, the advantages of the fast GPRS technology. The MC35 based GPRS modem GPRS35 is available now. During the 3Q 2002 RTD Finland will also release a triple band GPRS module that will operate in the 1900MHz band. The part number will be GPRS45. Engineering samples will be available in August 2002.

16C550 compatible UART

Communication to the GSM35 board is performed through a standard UART channel. This onboard serial port leaves the other system serial ports free for the user. All operating systems will recognize and support this 16C550 standard UART, and therefore no special communication drivers are needed to receive data from your GSM35 board. The address and interrupt of your serial channels can be individually set with the onboard jumper fields.

I/O interfaces

The GSM35 can be controlled and monitored from the software through two dedicated I/O registers. A special I/O connector is available for the user to connect to the general-purpose TTL level digital I/O.

Mechanical description

The GSM35 is designed on a PC/104 form factor. An easy mechanical interface to both PC/104 and RTD IDAN systems can be achieved. Stack your GSM35 directly on a PC/104 compatible CPU module using the onboard mounting holes and standoffs.

Connector description

The GPS and GSM antenna interfaces use an OSX type miniature coaxial connector. Connect your antenna directly to the GSM35 antenna connectors, or use a short cable inside your enclosure to connect to a feed through connector to allow connection of the antennas to the wall of your enclosure. All I/O connections are made using header type terminals.

What comes with your board

Your GSM35 package contains the following items:

- GSM35 board
- User's manual

Note: Device drivers and example software available on our website

If any item is missing or damaged, please send an EMAIL to Real Time Devices Finland sales service department at Internet address: <sales@rtdfinland.fi>.

Note that RTD Finland also can offer a GSM35 starter kit that will include an active antenna with ready cables for direct evaluation and testing of this module. The part number for this starter kit is ***SK-GSM35***.

Using this manual

This manual is intended to help you install your new GSM35 module and get it working quickly, while also providing enough detail about the board and it's functions so that you can enjoy maximum use of it's features even in the most demanding applications.

When you need help

This manual and all the example programs will provide you with enough information to fully utilize all the features on this board. If you have any problems installing or using this board, contact our Technical support department at <techsupport@rtdfinland.fi>. When sending us an Email request please include the following information: Your company's name and address, your name, your telephone number, and a brief description of the problem.

Chapter 2 - BOARD SETTINGS

The GSM35 board has jumper settings, which can be changed to suit your application and host computer configuration. The factory settings are listed and shown in the diagram at the beginning of this chapter. Make sure you completely study and understand this chapter before making changes to these settings.

Factory-Configured Jumper Settings

Table 2-1 below illustrates the factory jumper setting for the GSM35. Figure 2-1 shows the board layout of the GSM35 and the locations of the jumpers. The following paragraphs explain how to change the factory jumper settings to suit your specific application.

Table 2-1 Factory configured jumper settings (Please see figure 2-1 below for more detailed locations)

JUMPER NAME	DESCRIPTION	NUMBER OF JUMPERS	FACTORY SETTING
BASE	Base Addresses	6	2E8 / 6E8
IRQ	Host interrupts	11+1	5, G – jumper closed

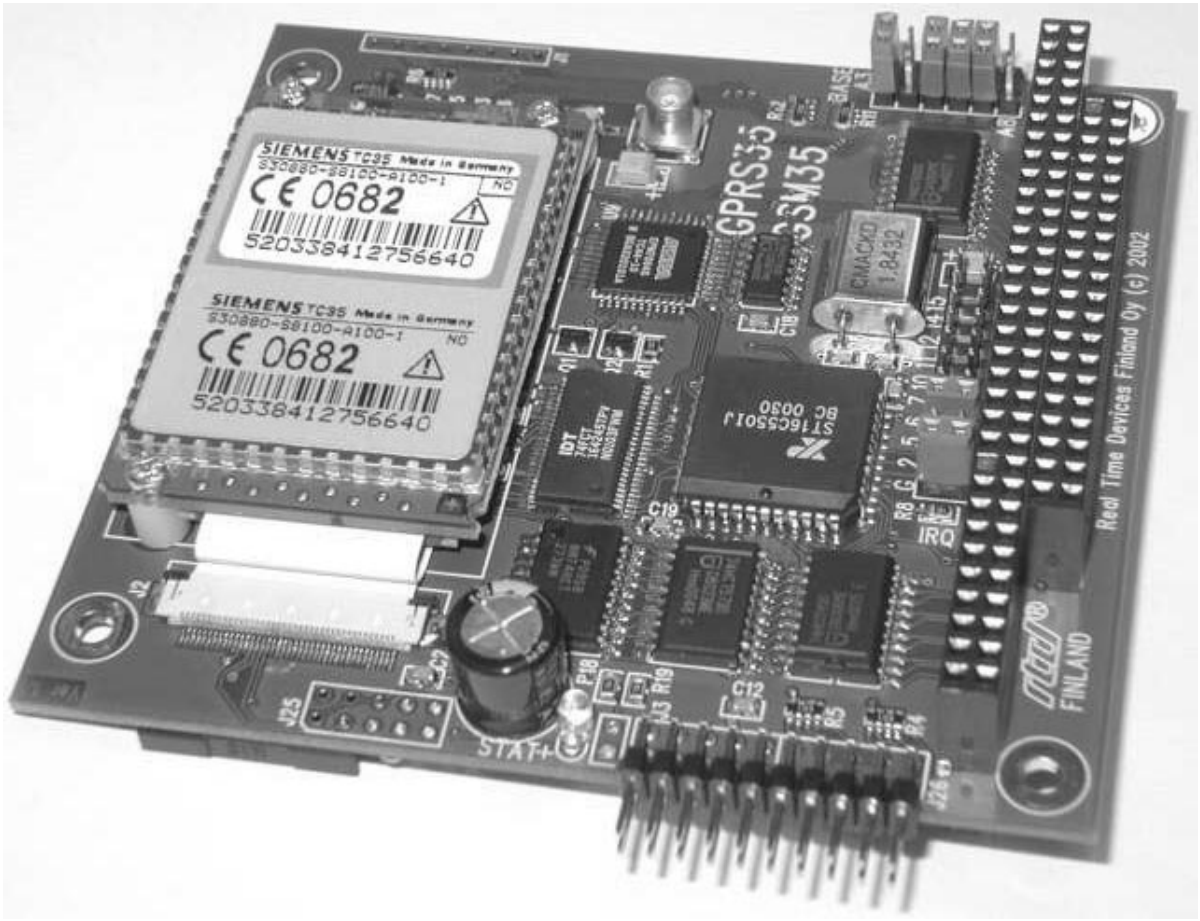

Fig. 2-1 GSM35-1 Board layout showing jumper locations

Base address jumpers (Factory setting: 2E8h / 6E8h)

The GSM35 is I/O mapped into the memory space of your host XT/AT. The board occupies a consecutive memory window of 8 bytes starting from the base address for UART communication and 4 consecutive bytes starting from BASE+400h for the board control and status registers. As an example if your base address is set to be 2E8h for the serial port, the onboard control registers will start from 6E8h.

The most common cause of failure when you are first setting up your module is address contention: some of your computers I/O space is already occupied by other devices and memory resident programs. When the GSM35 attempts to use it's own reserved memory addresses (which are being already used by another peripheral device) erratic performance can occur and the data read from the board may be corrupted.

To avoid this problem make sure you set up the base address by using the six jumpers on the right side of the board, this allows you to choose from a number of different addresses in your host computer's I/O map. Should the factory-installed settings be incompatible to your system configuration, you may change this setting to another using the options illustrated in Table 2-2 (overleaf). The table shows the jumper settings and their corresponding values in hexadecimal form. Ensure that you verify the correct location of the base address jumpers. When the jumper is removed it corresponds to a logical "0", connecting the jumper to a "1". When you set the base address of the module, record the setting inside the back cover of this manual.

GSM35 Base address configuration

BASE	A8	A7	A6	A5	A4	A3	BASE	A8	A7	A6	A5	A4	A3
200	0	0	0	0	0	0	300	1	0	0	0	0	0
208	0	0	0	0	0	1	308	1	0	0	0	0	1
210	0	0	0	0	1	0	310	1	0	0	0	1	0
218	0	0	0	0	1	1	318	1	0	0	0	1	1
220	0	0	0	1	0	0	320	1	0	0	1	0	0
228	0	0	0	1	0	1	328	1	0	0	1	0	1
230	0	0	0	1	1	0	330	1	0	0	1	1	0
238	0	0	0	1	1	1	338	1	0	0	1	1	1
240	0	0	1	0	0	0	340	1	0	1	0	0	0
248	0	0	1	0	0	1	348	1	0	1	0	0	1
250	0	0	1	0	1	0	350	1	0	1	0	1	0
258	0	0	1	0	1	1	358	1	0	1	0	1	1
260	0	0	1	1	0	0	360	1	0	1	1	0	0
268	0	0	1	1	0	1	368	1	0	1	1	0	1
270	0	0	1	1	1	0	370	1	0	1	1	1	0
278	0	0	1	1	1	1	378	1	0	1	1	1	1
280	0	1	0	0	0	0	380	1	1	0	0	0	0
288	0	1	0	0	0	1	388	1	1	0	0	0	1
290	0	1	0	0	1	0	390	1	1	0	0	1	0
298	0	1	0	0	1	1	398	1	1	0	0	1	1
2A0	0	1	0	1	0	0	3A0	1	1	0	1	0	0
2A8	0	1	0	1	0	1	3A8	1	1	0	1	0	1
2B0	0	1	0	1	1	0	3B0	1	1	0	1	1	0
2B8	0	1	0	1	1	1	3B8	1	1	0	1	1	1
2C0	0	1	1	0	0	0	3C0	1	1	1	0	0	0
2C8	0	1	1	0	0	1	3C8	1	1	1	0	0	1
2D0	0	1	1	0	1	0	3D0	1	1	1	0	1	0
2D8	0	1	1	0	1	1	3D8	1	1	1	0	1	1
2E0	0	1	1	1	0	0	3E0	1	1	1	1	0	0
2E8	0	1	1	1	0	1	3E8	1	1	1	1	0	1
2F0	0	1	1	1	1	0	3F0	1	1	1	1	1	0
2F8	0	1	1	1	1	1	3F8	1	1	1	1	1	1

0 = JUMPER OFF **1 = JUMPER CLOSED**

Table 2-2 Base address jumper settings for the GSM35, the default jumper setting is highlighted.

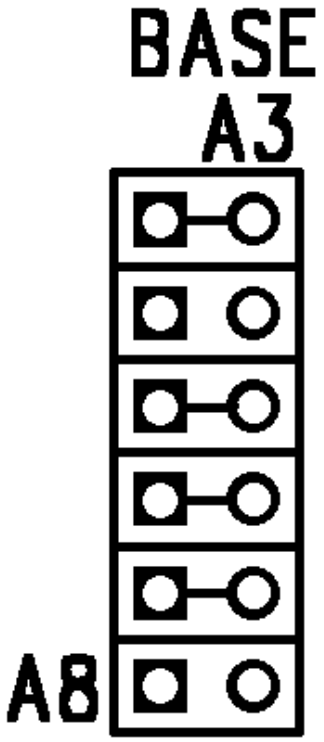

Fig. 2-2 Base address jumpers illustrating address 2E8

Host interrupts (Factory setting: IRQ5, G closed)

The header connector, shown in Figure 2-3 below, lets you connect the onboard control logic interrupt outputs to one of the interrupt channels available on the host computer XT/AT bus.

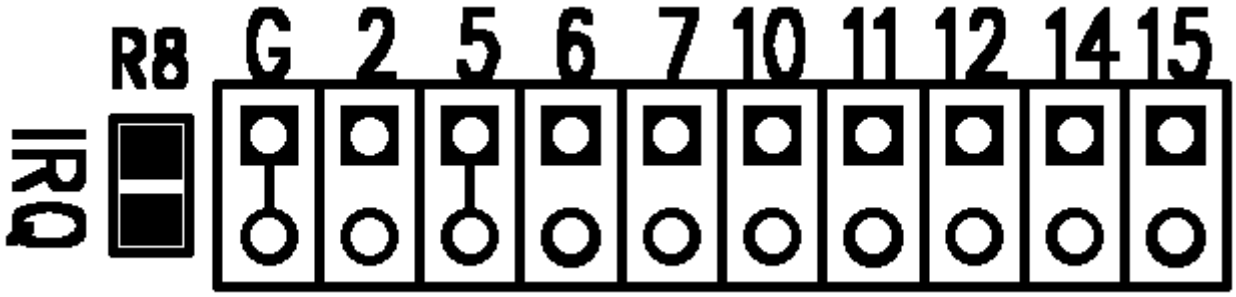

Fig. 2-3 Interrupt jumpers from left to right IRQ2,5,6,7,10,11,12,14,15 and G

Note: The GSM35 hardware supports interrupt sharing! Jumper G must be closed on one module per used interrupt. For example if two boards share interrupt number 7 only one board may have the G jumper closed. The G jumper connects a 1KOhm resistor to ground while the shared interrupts are 3-stated pulling the line to an inactive level.

Chapter 3 BOARD INSTALLATION

The GSM35 GSM modem module is designed to directly mount on top or under your RTD PC/104 cpuModule stack. This chapter tells you step-by-step how to install your GSM35 into your system.

Board installation

Keep your board in its antistatic bag until you are ready to install it to your system! When removing it from the bag, hold the board at the edges and do not touch the components or connectors. Please handle the board in an antistatic environment and use a **grounded** workbench for testing and handling of your hardware. Before installing the board in your computer, check the power cabling. Failure to do so may cause the power supply unit to malfunction or even cause permanent damage.

General installation guidelines:

- Touch the grounded metal housing of your computer to discharge any antistatic buildup and then remove the board from its antistatic bag.
- Hold the board by the edges and install it in an enclosure or place it on the table on an antistatic surface
- Install your board in your system, and wire the power supply correctly. Failure to do so may cause the power supply unit to malfunction or even cause permanent damage to the device.
- Check all wiring connections once and then once more again
- Connect the SIM card and the GSM antenna to the OSX connector on the GSM35 board
- Apply power to your system

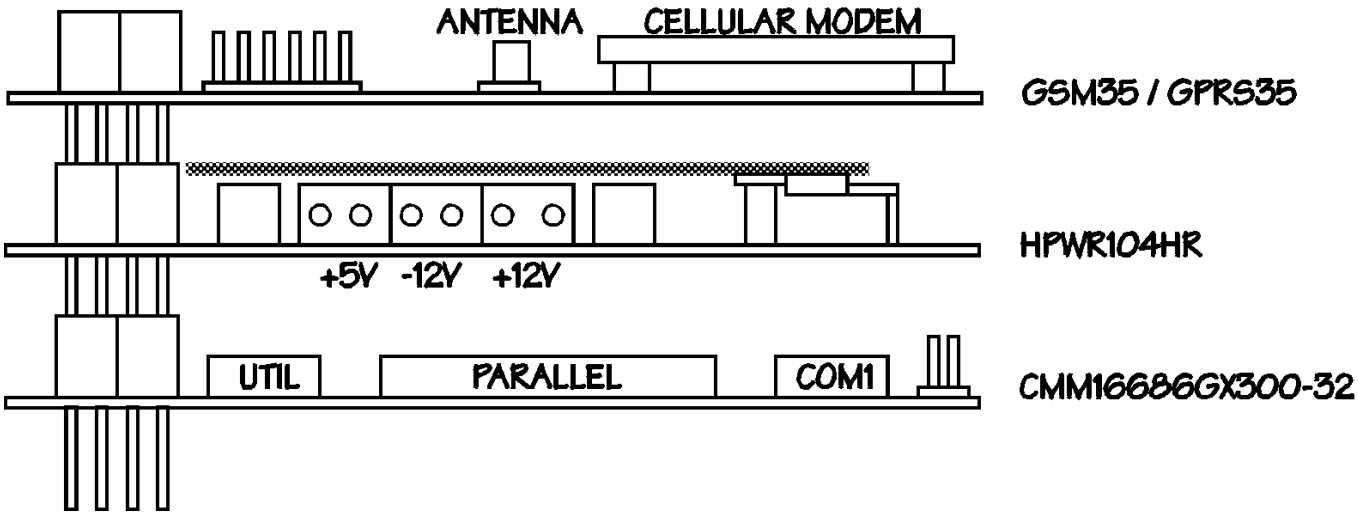

Fig. 3-1 GSM35 integrated in a RTD PC/104 cpuModule stack together with a HPWR104HR power supply module and a CMM series cpuModule

General purpose digital I/O connector

The Table 3-1 below shows the pin outs of the GSM35 digital I/O interface. The signals in this geader connector can be used as general purpose TTL level I/O lines to interface to LCD displays, LED's, bush buttons or relays. Note that Figure 3-2 shows two connectors together. The connector J28 carries all inputs and J3 carries all the outputs.

PIN J2	**Description**	**PIN J2**	**Description**
1	GND	2	Out0
3	Out1	4	Out2
5	Out3	6	Out4
7	Out5	8	Out6
9	Out7	10	+5V
PIN J16	**Description**	**PIN J16**	**Description**
1	GND	2	In0
3	In1	4	In2
5	In3	6	In4
7	In5	8	In6
9	In7	10	+5V

Table 3-1 Pin outs of the GSM35 digital I/O interface connector

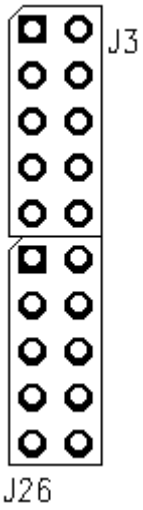

Fig 3-2 Digital I/O connector layout of the GSM35

SIM card holder

The figure 3-3 below shows the mechanical construction of the +3V standard SIM-card holder. In the figure the card is in the ejected state. Press the card carrier into the holder. To eject the SIM-card, press the yellow ejector button. The GSM35 also supports an external SIM card interface board the ESIM2035. This external card interface can be attached to the wall of your enclosure with a 150mm long cable. This is the maximum guaranteed length.

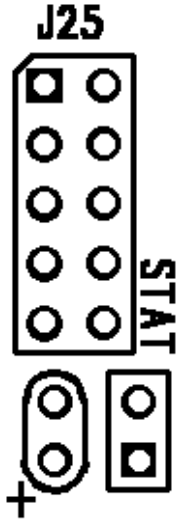

Fig 3-3 External SIM card interface of the GSM35.

Figure 3-4 below shows a picture of the external SIM card interface board.

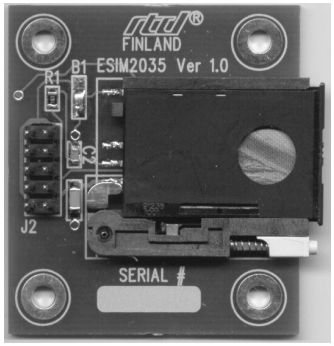

Fig 3-4 ESIM2035 board

Note that the ESIM2035 is configured differently for the GSM20 and the GSM35/GPRS35. The units are not interchangeable, the GSM35 and the GPRS are identical in their SIM interfaces. Once the TC35 GSM modem is able to initialise itself after power-up and correctly detect the SIM card the green status LED will be lit. If the LED is not illuminated you can not interface to your GSM modem. See Figure 3-3 for the location of the "STAT" LED. The header/mounting holes immediately next to the LED can be used to connect to an LED externally mounted to the enclosure wall for example. The "STAT" LED will not indicate detection of the GSM field or network access.

External SIM card interface J25

The figure 3-4 below shows the GSM35 external SIM card interface header J25 that is used to connect to board the ESIM2035.

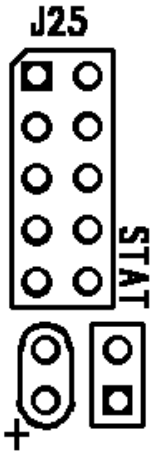

Fig 3-5 External SIM card header J25 available only on GSM35-2 boards

Chapter 4 - HARDWARE DESCRIPTION

This chapter describes the major hardware building blocks of the GSM35:

- The GSM wireless modem module
- GSM antenna considerations
- SIM card reader
- UART serial port circuitry
- Digital I/O

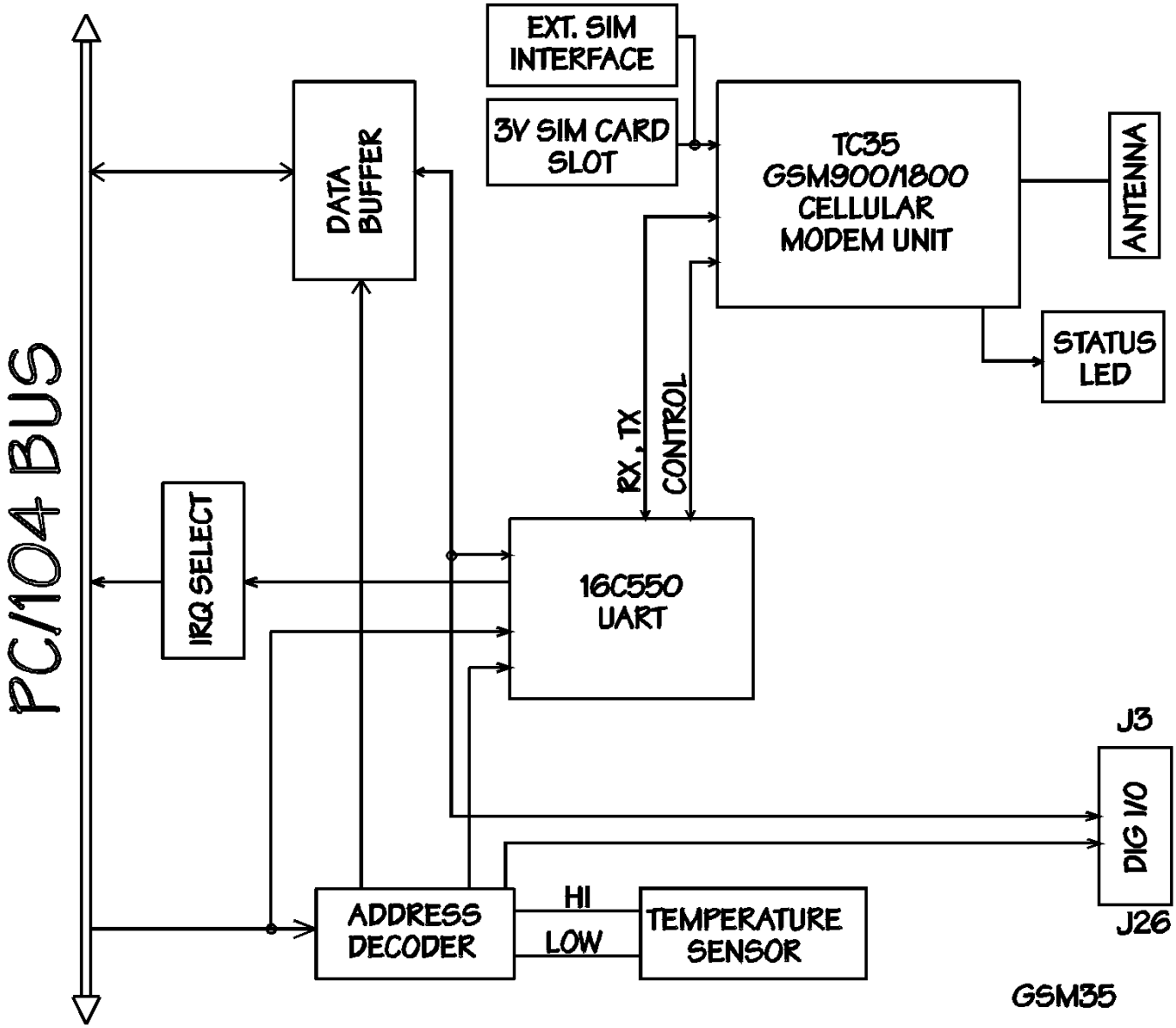

Fig. 4-1 Block diagram of the GSM35

The GSM wireless modem module

The GSM35 wireless GSM modem is built around the Siemens TC35 dual band 900/1800MHz cellular engine. It is designed both for handling complex industrial applications such as telemetry, telematics or communication, and for integration in stationary or mobile fields all over the world. General information on these products is available at the following Internet addresses: http://www.siemens.de/gsm_e and http://www.siemens.de/gsm in german language.

The GSM35 is capable of powerful communication over a speed of 9,6 kbps or CSD up to 14,4 kbps (as of 06/2001). It is capable of FAX and SMS text messages. The data terminal rate is 9600 baud for all host commands (AT commands). The GSM35 modem module antenna interface connector uses an OSX connector. The mating antenna connectors and cables are supplied from RTD Finland Oy. Temperature monitoring is possible using the onboard temperature sensor. Limit data can be interrogated from the GSM35 status register bits 2-3.

GSM Antenna considerations

The antenna used must meet the following specifications: Frequency 890-910 MHz (TX), 935-960MHz (RX); Impedance 50 Ohms; VSWR 1,7:1 (TX) 1,9:1 (RX); Gain <1,5dB references to 1/2-dipole; 1W power (cw) max 2W peak at 55 degrees Centigrade. Typically standard GSM antennas use a female FME connector. This connector needs an adapter unit before it can be connected to the GSM35.

RTD Finland Oy recommends the use of high quality antennas with the GSM35. We have tested successfully with antennas from Hirschmann Rheinmetall Elektronik.

Visit http://www.hirschmann.de/ for information on GSM antennae.

A very useful AT command that shows quality of the signal reception is : AT+SCQ, the signal quality +CSQ: value (Value should be > 11) shows the quality of the network signal.

SIM-card reader

Standard 3V and dual voltage SIM-cards can be used with the GSM35. Older 5V SIM cards will not work, though they may operate in standard GSM cellular phones. These new 3V SIM cards are no older than two years. The SIM-card holder has a card detection circuit that will in theory allow hot insertion and removal of the card. This is **NOT** recommended, since the SIM card contenets can become corrupted if it is removed while the TC35 GSM modem is writing to it.

A very useful AT command that shows detestion of the SIM card is: **AT^SCID**. The SIM card identifier is given as a reply **^SCID: value** shows the ID of the SIM card. If no ID is detected the TC35 can not read the SIM card and can not connect to the GSM service provider network.

To add an entry to your SIM card you may use the AT+CPBW command. In this example we add the RTD Finland phone number +358 9 346 4538 to the SIM card memory location "1" with the following AT command set:

AT+CPBW=1,35893464538,145,RTDFinland

AT+CREG? Will indicate if the GSM35 is logged into the network. If the reply for example is **+CREG: 0,1** it means that connection to the home network is valid. A complete AT-instruction set documentation is included in the TC35 user's manual.

UART serial port circuitry

GSM data is sent and received through a standard 16C550 compatible UART. All today's operating systems will recognize and support this serial communication device. The GSM35 uses its own onboard serial port and will not reserve serial port resources from the system. The I/O base address and interrupt for this serial port can be flexibly set as has been described in previous chapters of this manual. This user's manual will not wade into details of serial port programming. This information is commonly available today. You can use any communication software package or terminal program to connect to your GSM35 UART. Just make sure you set up the I/O and IRQ are set right. The correct terminal speed for AT commands is 9600 baud, 8 databits, no parity, one stopbit, and hardware handshake. The UART on the board is specified for full operation from –40 to +85C. The oscillator frequency is set to be 1.8432MHz. Note that the UART interrupt can be disabled or enabled from software by writing to bit 01 in address BASE+0x402.

Digital I/O

For general-purpose digital I/O interfacing a 16-bit digital I/O port is provided. This port includes 8 TTL-level digital outputs that are cleared (to 0) after system reset. Also are included 8 digital inputs with 10K Ohm pull-down resistors. These I/O's are located on the left side of the board. These I/O's are ideal to be used to interface to LCD displays, LED's pushbuttons or other low power controls.

Chapter 5 BOARD OPERATION AND PROGRAMMING

This chapter shows you how to program and use your GSM35. It provides a general description of the I/O map. Detailed serial port programming tips are not within the scope of this manual.

Defining the Memory Map

The memory map of the GSM35 occupies two groups of eight bytes of host PC I/O space. This window is freely selectable by the user as described in *Chapter 2, Table 2-2.* After setting the base address you have access to the internal resources of the GSM35 control logic. These resources are not described in detail, since they are mapped as a standard PC serial port. For more details on the EXAR ST16C550IJ44 UART chip programming please download the component specific data t from the website: http://www.exar.com/products/st16c550.html

ADDR (hex)	REGISTER	DIR	COMMENTS
BASE	TXD	O	Only if control reg. Bit 7=0
	RXD	I	Only if control reg. Bit 7=0
	BAUD div. Low		Only if control reg. Bit 7=1
BASE+1	BAUD div. High		Only if control reg. Bit 7=1
	IRQ enable		Only if control reg. Bit 7=0
BASE+2	IRQ ID		
BASE+3	Line control		
BASE+4	Modem control		
BASE+5	Line status		
BASE+6	Modem status		
BASE+400	Digital I/O	I/O	Digital I/O port
BASE+402	GSM status	I/O	Configuration registers
BASE+403	GSM control	I/O	Power control

Table 5-1a General I/O map of the GSM35 UART

BASE+400 Digital I/O (R/W)

This address is used to interface to the digital I/O port of the GSM35, writing to this address will transfer the data out of the output port, while reading from this address will return the data from the digital inputs.

BASE+402 GSM Status (R/W, 0x00 after reset)

Write

Bit 0	RESERVED	
Bit 1	/EN_INT	0 – UART interrupt enabled; 1 - disabled
Bit 2	RESERVED	
Bit 3	RESERVED	

Read

Bit 0	/EN_RST	state
Bit 1	/EN_INT	state
Bit 2	TEMP_LOW	1 - Board temperature below –20C
Bit 3	TEMP_HIGH	1 - Board temperature over +70C

BASE+403 GSM Control (R/W, 0x00 after reset)

Write

Bit 0	Ignition signal	1 – > 0 – results in IGN signal
Bit 1	Powerdown of the TC35	1 – Power down; 0 – Power on
Bit 2	RESERVED	
Bit 3	RESERVED	

Read

Bit 0	Ignition signal	state
Bit 1	Powerdown of the TC35	state
Bit 2	RESERVED	
Bit 3	RESERVED	

Starting up and logging into the GSM network

With no power applied insert your +3V or dual voltage SIM into the card-holder on the solder side of the board. Connect the antenna cable to the TC35 antenna connector and power up your PC/104 system. The GSM35 will initioalise with the system. After this the status LED will blink for a while until the TC35 is logged into the network. If you have the PIN code enabled, the GSM35 status LED will continue to blink until the PIN code is given through the terminal mode with AT command **AT+CPIN"XXXX",** unless **AT^SFLC** (facility lock for PIN code) has been set. Once the GSM35 is logged onto the network the LED will be lit continuously.

INTERRUPTS

What is an interrupt?

An interrupt is an event that causes the processor in your computer to temporarily halt its current process and execute another routine. Upon completion of the new routine, control is returned to the original routine at the point where its execution was interrupted.

Interrupts are a very flexible way of dealing with asynchronous events. Keyboard activity is a good example; your computer cannot predict when you might press a key and it would be a waste of processor time to do nothing whilst waiting for a keystroke to occur. Thus the interrupt scheme is used and the processor proceeds with other tasks. When a keystroke finally occurs, the keyboard then 'interrupts' the processor so that it can get the keyboard data. It then places it into the memory, and then returns to what it was doing before the interrupt occurred. Other common devices that use interrupts are A/D boards, network boards, other used serial ports etc.

Interrupt request lines

To allow different peripheral devices to generate interrupts on the same computer, the PC AT bus has interrupt request channels (IRQ's). A rising edge transition on one of these lines will be latched into the interrupt controller. The interrupt controller checks to see if the interrupts are to be acknowledged from that IRQ and, if another interrupt is being processed, it decides if the new request should supercede the one in progress or if it has to wait until the one in progress has been completed. The priority level of the interrupt is determined by the number of the IRQ as follows; IRQ0 has the highest priority whilst IRQ15 has the lowest. Many of the IRQ's are already used by the standard system resources, IRQ0 is dedicated to the internal timer, IRQ1 is dedicated to the keyboard input,

IRQ3 for the serial port COM2, and IRQ4 for the serial port COM1. Often interrupts 2,5,7,10,11 and 15 are free for the user.

8259 Programmable Interrupt Controller

The chip responsible for handling interrupt requests in a PC is the 8259 Interrupt Controller. To use interrupts you will need to know how to read and set the 8259's internal interrupt mask register (IMR) and how to send the end-of-interrupt (EOI) command to acknowledge the 8259 interrupt controller.

Interrupt Mask Register (IMR)

Each bit in the interrupt mask register (IMR) contains the mask status of the interrupt line. If a bit is set (equal to 1), then the corresponding IRQ is masked, and it will not generate an interrupt. If a bit is cleared (equal to 0), then the corresponding IRQ is not masked, and it can then generate an interrupt. The interrupt mask register is programmed through **port 21h**.

End-of-Interrupt (EOI) Command

After an interrupt service routine is complete, the 8259 Interrupt Controller must be acknowledged by writing the value 20h to port 20h.

What exactly happens when an interrupt occurs?

Understanding the sequence of events when an interrupt is triggered is necessary to correctly write interrupt handlers. When an interrupt request line is driven high by a peripheral device (such as the GSM35), the interrupt controller checks to see if interrupts are enabled for that IRQ. It then checks to see if other interrupts are active or requested and determines which interrupt has priority. The interrupt controller then interrupts the processor. The current code segment (CS), instruction pointer (IP), and flags are pushed onto the system stack, and a new set if CS and IP are loaded from the lowest 1024 bytes of memory.

This table is referred to as the interrupt vector table and each entry to this table is called an interrupt vector. Once the new CS and IP are loaded from the interrupt vector table, the processor starts to execute code from the new Code Segment (CS) and from the new Instruction Pointer (IP). When the interrupt routine is completed, the old CS and IP are popped from the system stack and the program execution continues from the point where interruption occurred.

Using Interrupts in your Program

Adding interrupt support to your program is not as difficult as it may seem especially when programming under DOS. The following discussion will cover programming under DOS. Note that even the smallest mistake in your interrupt program may cause the computer to hang up and will only restart after a reboot. This can be frustrating and time-consuming.

Writing an Interrupt Service Routine (ISR)

The first step in adding interrupts to your software is to write an interrupt service routine (ISR). This is the routine that will be executed automatically each time an interrupt request occurs for the specified IRQ. An ISR is different from other sub-routines or procedures. First on entrance the processor registers must be pushed onto the stack before anything else! Second, just before exiting the routine, you must clear the interrupt on the GSM35 by writing to the Status register, and write the EOI command to the interrupt controller. Finally, when exiting the interrupt routine the processor registers must be popped from the system stack and you must execute the IRET assembly instruction. This instruction pops the CS, IP and processor flags from the system stack. These were pushed onto the stack when entering the ISR.

Most compilers allow you to identify a function as an interrupt type and will automatically add these instructions to your ISR with one exception: most compilers do not automatically add the EOI command to the function, you must do it yourself. Other than this and a few exceptions discussed below, you can write your ISR as any code routine. It can call other functions and procedures in your program and it can access global data. If you are writing your first ISR, we recommend you stick to the basics; just something that enables you to verify you have entered the ISR and executed it successfully. For example: set a flag in your ISR and in your main program check for the flag.

Note: If you choose to write your ISR in in-line Assembly, you must push and pop registers correctly and exit the routine with the IRET instruction instead of the RET instruction.

There are a few precautions you must consider when writing ISR's. The most important is, **do not use any DOS functions or functions that call DOS functions from an interrupt routine.** DOS is not re-entrant; that is, a DOS function cannot call itself. In typical programming, this will not happen because of the way DOS is written. But what about using interrupts? Consider then the following situation in your program: If DOS function X is being executed when an interrupt occurs and the interrupt routine makes a

call to the same DOS function X, then function X is essentially being called while active. Such cases will cause the computer to crash. DOS does not support such operations. The general rule is that do not call any functions that use the screen, read keyboard input or any file I/O routines, these should not be used in ISR's.

The same problem of re-entrancy also exists for many floating-point emulators. This effectively means that you should also avoid floating point mathematical operations in your ISR.

Note that the problem of reentrancy exists, no matter what programming language you use. Even, if you are writing your ISR in Assembly language, DOS and many floating point emulators are not re-entrant. Of course there are ways to avoid this problem, such as those which activate when your ISR is called. Such solutions are, however, beyond the scope of this manual.

The second major concern when writing ISR's is to make them as short as possible in term of execution time. Spending long times in interrupt service routines may mean that other important interrupts are not serviced. Also, if you spend too long in your ISR, it may be called again before you have exited. This will lead to your computer hanging up and will require a reboot.

Your ISR should have the following structure:

- Push any processor registers used in your ISR.
- Put the body of your routine here
- Clear the interrupt bit by reading GSM35 RXD register
- Issue the EOI command to the 8259 by writing 20h to 20h
- Pop all registers. Most C compilers do this automatically

The following C example shows what the shell of your ISR should be like:

```
/*---------------------------------------------------------------------------
| Function:    new_IRQ_handler
| Inputs:      Nothing
| Returns:     Nothing
|---------------------------------------------------------------------------*/
void interrupt far new_IRQ_handler(void)
{
        IRQ_flag = 1;          // Indicate to process interrupt has occurred

        {
                               // Your program code to read UART
                               // read to a data buffer for example:
        Guc_buffer[Gi_bufpos++] = inp(gi_SERIAL_DATA);
        }
        outp(0x20, 0x20);      // Acknowledge the interrupt controller
}
```

Saving the Startup Interrupt Mask Register (IMR) and interrupt vector

The next step after writing the ISR is to save the startup-state of the interrupt mask register, (IMR) and the original interrupt vector you are using. The IMR is located in address 21h. The interrupt vector you will be using is located in the interrupt vector table which is an array of pointers (addresses) and it is locate din the first 1024 bytes of the memory (Segment 0 offset 0). You can read this value directly, but it is better practice to use DOS function 35h (get interrupt vector) to do this. Most C compilers have a special function available for doing this. The vectors for the hardware interrupts on the XT - bus are vectors 8-15, where IRQ0 uses vector 8 and IRQ7 uses vector 15. Thus if your GSM35 is using IRQ5 it corresponds to vector number 13.

Before you install your ISR, temporarily mask out the IRQ you will be using. This prevents the IRQ from requesting an interrupt while you are installing and initializing your ISR. To mask the IRQ, read the current IMR at I/O port 21h, and set the bit that corresponds to the IRQ. The IMR is arranged so that bit 0 is for IRQ0 and bit 7 is for IRQ7. See the paragraph entitled *Interrupt Mask Register (IMR*) earlier in this discussion for help in determining your IRQ's bit. After setting the bit, write the new value to I/O port 21h.

With the startup IMR saved and the interrupts temporarily disabled, you can assign the interrupt vector to point to your ISR. Again you can overwrite the appropriate entry in the vector table with a direct memory write, but this is not recommended. Instead use the DOS function 25h (Set Interrupt Vector) or, if your compiler provides it, the library routine for setting up interrupt vectors. Remember that interrupt vector 8 corresponds to IRQ0, vector 9 for IRQ1 etc.

If you need to program the source of your interrupts, do that next. For example, if you are using transmitted or received messages as an interrupt source program it to do that. Finally, clear the mask bit for your IRQ in the IMR. This will enable your IRQ.

Common Interrupt mistakes

Remember hardware interrupts are from 8-15, XT IRQ's are numbered 0-7. Do not forget to clear the IRQ mask bit in the IMR Forgetting to send the EOI command after ISR code. Disables further interrupts.

Example on Interrupt vector table setup in C-code:

```
void far _interrupt new_IRQ1_handler(void );            /* ISR function */
#define IRQ1_VECTOR     3                               /* Name for IRQ */
void (interrupt far *old_IRQ1_dispatcher)
        (es,ds,di,si,bp,sp,bx,dx,cx,ax,ip,cs,flags);    /* Variable to store
old IRQ_Vector */
void far _interrupt new_IRQ1_handler(void );

/*---------------------------------------------------------------------
| Function:    init_irq_handlers
| Inputs:      Nothing
| Returns:     Nothing
| Purpose:     Set the pointers in the interrupt table to point to
|              our funtions ie. setup for ISR's.
|---------------------------------------------------------------------*/
void init_irq_handlers(void)
{
        _disable();
                old_IRQ1_handler = _dos_getvect(IRQ1_VECTOR + 8);
                _dos_setvect(IRQ1_VECTOR + 8, new_IRQ1_handler);
                Gi_old_mask = inp(0x21);
                outp(0x21,Gi_old_mask & ~(1 << IRQ1_VECTOR));
        _enable();
}


|/*---------------------------------------------------------------------
| Function:    restore, do this before exiting program
| Inputs:      Nothing
| Returns:     Nothing
| Purpose:     Restore the interrupt vector table.
|---------------------------------------------------------------------*/
void restore(void)
{
        /* Restore the old vectors */
        _disable();

                _dos_setvect(IRQ1_VECTOR + 8, old_IRQ1_handler);
                outp(0x21,Gi_old_mask);

        _enable();
}
```

Chapter 6 - GSM35 SPECIFICATIONS

Host interface

16-bit PC/104 bus, XT-bus used for data, XT and AT interrupts available

GSM modem specifications

Operational

GSM compatibility	EGSM900 and GSM1800 phase 2/2+
Datarate	9600 baud, 14400 baud CSD
Services supported	GSM data transmisson, SMS, Fax group 3
Network personalisation	GSM 02.22
Status indicator	1 LED
Output power	Class 4 (4W) EGSM900 Class 1 (1W) GSM1800

SIM card reader

Voltage	3V or dual voltage cards
Compatibility	GSM11.11 and 11.12
Detection	SIM card detection supported

Antenna Interface

Impedance	50 Ohms
VSWR	TX: max 1.7:1 installed RX: max 1.9:1 installed
Gain	> 1.5dB, referenced to 1/2L dipole
3dB width of cone	vertical 80 deg , horizontal 360 deg
Maximum power	1W (cw), 2 W peak at +55C ambient
Connector	OSX

UART and I/O

UART compatibility	16C550 compatible
Oscillator frequency	1.8432MHz
Connection	Full hardware handshaking supported
Base addresses	32+4
Interrupts	2,5,7,10,11,12,14 and 15
Digital I/O	8 TTL outputs, 8 TTL inputs w. 10K pull-down

GSM35 Electromechanical

Operating temperature range	-20 to +70 C, for the GSM operation
Humidity	RH up to 95% non condensing
Altitude	-1000 to 60.000 ft
Vibration	Survival 10G peak
Power consumption	2,3W min

Chapter 7 - RETURN POLICY AND WARRANTY

Return Policy

If the module requires repair, you may return it to us by following the procedure listed below:

Caution:	Failure to follow this return procedure will *almost always* delay repair! Please help us expedite your repair by following this procedure.

1) Read the limited warranty, which follows.

2) Contact the factory and request a Returned Merchandise Authorization (RMA) number.

3) On a sheet of paper, write the name, phone number, and fax number of a technically competent person who can answer questions about the problem.

4) On the paper, write a detailed description of the problem with the product. Answer the following questions:

- Did the product ever work in your application?
- What other devices were connected to the product?
- How was power supplied to the product?
- What features did and did not work?
- What was being done when the product failed?
- What were environmental conditions when the product failed?

5) Indicate the method we should use to ship the product back to you.

- We will return warranty repairs by UPS Ground at our expense.
- Warranty repairs may be returned by a faster service at your expense.
- Non-warranty repairs will be returned by UPS Ground or the method you select, and will be billed to you.

6) Clearly specify the address to which we should return the product when repaired.

7) Enclose the paper with the product being returned.

8) Carefully package the product to be returned *using anti-static packaging!* We will not be responsible for products damaged in transit for repair.

7) Write the RMA number on the outside of the package.

8) Ship the package to:

Real Time Devices Finland Oy

Lepolantie 14

FIN-00660 Helsinki

FINLAND

Limited Warranty

Real Time Devices, Inc. warrants the hardware and software products it manufactures and produces to be free from defects in materials and workmanship for one year following the date of shipment from REAL TIME DEVICES. This warranty is limited to the original purchaser of product and is not transferable.

During the one year warranty period, REAL TIME DEVICES will repair or replace, at its option, any defective products or parts at no additional charge, provided that the product is returned, shipping prepaid, to REAL TIME DEVICES. All replaced parts and products become the property of REAL TIME DEVICES. Before returning any product for repair, customers are required to contact the factory for an RMA number.

THIS LIMITED WARRANTY DOES NOT EXTEND TO ANY PRODUCTS WHICH HAVE BEEN DAMAGED AS A RESULT OF ACCIDENT, MISUSE, ABUSE (such as: use of incorrect input voltages, improper or insufficient ventilation, failure to follow the operating instructions that are provided by REAL TIME DEVICES, "acts of God" or other contingencies beyond the control of REAL TIME DEVICES), OR AS A RESULT OF SERVICE OR MODIFICATION BY ANYONE OTHER THAN REAL TIME DEVICES. EXCEPT AS EXPRESSLY SET FORTH ABOVE, NO OTHER WARRANTIES ARE EXPRESSED OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, ANY IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, AND REAL TIME DEVICES EXPRESSLY DISCLAIMS ALL WARRANTIES NOT STATED HEREIN. ALL IMPLIED WARRANTIES, INCLUDING IMPLIED WARRANTIES FOR MECHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, ARE LIMITED TO THE DURATION OF THIS WARRANTY. IN THE EVENT THE PRODUCT IS NOT FREE FROM DEFECTS AS WARRANTED ABOVE, THE PURCHASER'S SOLE REMEDY SHALL BE REPAIR OR REPLACEMENT AS PROVIDED ABOVE. UNDER NO CIRCUMSTANCES WILL REAL TIME DEVICES BE LIABLE TO THE PURCHASER OR ANY USER FOR ANY DAMAGES, INCLUDING ANY INCIDENTAL OR CONSEQUENTIAL DAMAGES, EXPENSES, LOST PROFITS, LOST SAVINGS, OR OTHER DAMAGES ARISING OUT OF THE USE OR INABILITY TO USE THE PRODUCT.

SOME STATES DO NOT ALLOW THE EXCLUSION OR LIMITATION OF INCIDENTAL OR CONSEQUENTIAL DAMAGES FOR CONSUMER PRODUCTS, AND SOME STATES DO NOT ALLOW LIMITATIONS ON HOW LONG AN IMPLIED WARRANTY LASTS, SO THE ABOVE LIMITATIONS OR EXCLUSIONS MAY NOT APPLY TO YOU.

THIS WARRANTY GIVES YOU SPECIFIC LEGAL RIGHTS, AND YOU MAY ALSO HAVE OTHER RIGHTS, WHICH VARY FROM STATE TO STATE.